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Tools for Collaboration Across STEM Fields

James A. Ejiwale*
Jackson State University

Abstract

Supporting learners at different stages of learning is essential to achieve positive learning, critical thinking, technical and problem solving skills, and gainful employment upon graduation. Collaboration is critical to providing strong foundational educational support to all learners as they advance to higher level of learning. More important is the need to promote collaboration among educators and other professionals across the Science, Technology, Engineering, and Mathematics (STEM) fields who educate the learners throughout their academic pursuit in their respective institutions of learning. To reap the value in diverse teams, the promotion of emergent interdependence fosters seamless collaborative activities across STEM disciplines. This paper addresses knowledge sharing among collaborators, the educational aspects of research facilities, and research clusters as some of the tools necessary to develop program through collaboration in STEM fields.

Keywords: collaboration, knowledge sharing, research clusters

*James A. Ejiwale, Associate Professor, Jackson State University, College of Science, Engineering, & Technology, Department of Technology, Jackson, MS 39217
e-mail: james.a.ejiwale@jsums.edu

Introduction

Collaboration is the vehicle for sharing responsibility and combining knowledge, creativity, and experience of others (Stowell 2005). Collaboration can build a seamless support system across the STEM disciplines. The recognition is growing in academics and business that pooling the ideas, resources, commitment and efforts of many is more effective than relying on the few best individuals. From this perspective, collaborators will bring a shared understanding of contextual influences on their differing background to their programmatic efforts. Collaboration can eliminate redundancy and overlapping that results in inefficient use of resources and the duplication of services (Gallagher, Clifford, & Maxwell, 2004). "Like all successful organizational activity, collaboration requires planning… Through planning, a common goal is determined as well as expectations for each participating agency or organization" (Melton 2001).

Why collaborate?

Perhaps the most important concepts around the issue of collaboration and resource sharing are found in understanding why collaboration should occur in the first place (Melton 2002). Therefore, it is important to note that collaboration:

- enhances services, especially for underserved disciplines that are not well funded or are not good in grant-manship to procure necessary research equipment.
- increases the quantity of resources available to serve clients or participating disciplines.
- increases better use of available resources.
- increases the quality of available services.
- enables STEM disciplines to address their common interests and common goals in providing services to cluster constituents.
- increases opportunities for knowledge sharing and exchange, thereby increasing knowledge awareness, sensitivity and competence.
- helps to view everyone as a resource.

The new industrial revolution has made important to prepare the present and future workforce with the required technical skills and knowledge necessary to support the emerging field. Given the need to prepare IT program graduates with skills necessary to function in the capacity of a technologist, manager or supervisor in any organization that desire to implement emerging technologies, it is necessary for faculty of STEM disciplines to work collaboratively to develop and propose courses that will enhance needed and necessary industrial technical skills and experience in the industrial technology undergraduate program. Since hands-on activities of any course will be enhanced through prolific research endeavors, interdisciplinary research clusters utilizing the core research facilities in that institution will help prepare and put our graduates at the forefront of employment in the new industrial revolution. According to Marchand (2009) who reported based on a business academic's point of view, an examination of the way in which 169 countries, 37 funding institutions and 2,500 scientists worked together through effective collaboration has given an insight into the benefits and characteristic of successful program development and leadership by collaboration. For such a diverse collaboration to produce incredible results, some potential barriers must be identified and broken.

Team leadership through collaboration and harmony

Establishing collaborative relationships is not always natural or easy, particularly because people have different lifestyles, backgrounds, and experiences (Stowell 2005). Since scholars across the STEM fields differ in so my ways given their diverse background and leaders of their respective disciplines, leadership through collaboration and harmony must be fostered. According to Stowell (2005) in his article titled Collaboration – A leadership skill development posited that "One of the most important things a leader needs to be able to do to collaborate with his/her team members is create a culture where members value and listen to alternative views and seek out win-win objectives. This can be accomplished by clearly identifying common needs and objectives; and certainly should occur on multiple occasions over time."

To this effect, participants in this collaborative effort must learn first hand to participate without formal authority or bias based on discipline. There should be a consensus on who will lead and with the understanding of all members or participants on the fact that this designated person has no authority beyond that granted to him by the people who would work with him. However, he is recognized as the indisputable leader of the project, keeping all efforts on track to ensure that the collaboration garner the best out of its members. In this capacity, it behooves such a designated leader that will bring everybody together regardless of their field of specialization, will not rock the boat, willing to make sure that everybody feels that they are part of the process with a sense of belonging, and be willing and able to encourage members with the weakest link in the group through motivation and gentle guidance. In this type of forum, the team's leadership style should be more about facilitating stewardship. This is an environment that encourages participation and ideas rather than dictating and directing project evolution (Marchand 2009).

It is necessary to build consensus and harmony among the participants so as not to lose that persons talent or financial contributions that may be diverted else where. Marchand (2009) further opined that decisions have to be taken on consensus; keep everybody, with an enormous diversity of skills on board. Without that camaraderie and commitment from participants, it is impossible with a top-down management system. What works is the ability of the leader to know how to collaborate and develop effective partnerships with others (Stowell 2005).

Knowledge sharing and management among departmental scholars

To fully anticipate collaborative activity and diverse team success, such a diverse team need emergent interdependence, meaning that members on the team must develop the desire and expectation to work interdependently for the benefit of the team's work (Caruso & Woolley 2008). "A leader can also foster collaboration by encouraging active involvement and the free exchange of information. The leader, also, must set the tone by keeping an open mind to different ideas. Furthermore, when the team members engage in collaborative activities, it is essential for the leader to validate and reinforce the collaboration in order to sustain the behavior" (Stowell 2005). In addition, Chi-Ying Cheng, C., Sanchez-Burks, J. & Lee, F (2008) in their study proposed that reinforcing the compatibility between functional identities within a team facilitates access to functionally unique knowledge systems, which in turn increases team innovation, provide common ground to promote communication and collaboration among professionals working in STEM disciplines.

Rink, F., & Ellemers, N. (2008) posited a theoretical model to explain under which conditions different insights or approaches within a team do not necessarily undermine team cohesiveness or prevent the development of a common team identity, and can in fact even reinforce each other. To this effect, they reviewed a program of research that examined the formation of a common identity in new collaborations, as well as the extent to which teams accept newcomers who possess unique resources. The outcome of their research showed that clarity and congruence determine the likelihood that team members will maintain a common identity while they effectively use the differences among them and accommodate to team changes. In this vein, junior faculty should be encouraged to participate in all activities. Even more active roles should be assigned at their early stage on board to discover quickly their potential and areas that they might need help on. This theoretical model has been widely embraced by the social sciences, education, health, and it will definitely work well for other for other disciplines, STEM inclusive.

The potential of the individual members should be quickly identified, trusted respected and encouraged. It should be noted that contributions of the individual may differ given the nature and knowledge about the project or program to be developed. Regardless, synergism should be fostered by tapping into the individuals' strength rather than focusing on their weaknesses. Brainstorming for creativity and new ideas and initiatives should be encouraged so as to pool knowledge. For example, highly interdisciplinary and relevant activities on new industrial revolution at Jackson State University has synergized many disciplines such as physics, chemistry, biology, mathematics, technology and engineering with focus on the strength of the participants. This has led to the development and implementation of research clusters across science, technology, engineering, and mathematics (STEM) or simply the STEM fields. The research clusters listed in Table 1 with their subgroups depict the interdisciplinary areas of strength of the participants. The diversification of the scholars in their areas of expertise with varying background in the STEM fields has made possible knowledge sharing and management in many emerging fields. This new mindset would help to enhance major interdisciplinary activities through the following research clusters:

1. Applied Computational Sciences & Engineering/High Performance Computing
2. Environmental Science and Environmental Engineering
3. Nanoscale Sciences and Technology
4. Data Information, Security and Management

Table 1. Research Clusters and their subgroups

Cluster	***Cluster Subgroups***
Applied Computational Sciences & Engineering/High Performance Computing – This cluster investigates High Performance Computing Modernization	Computational Nanoscience, Molecular Electronic Structure/Computational Quantum, Chemistry Computational Engineering & Technology, Bioinformatics/ Genomics
Environmental Science and Engineering – This cluster conduct research on today's environmental problems and appropriately disseminating research findings.	Bio-Phyto Remediation, Environmental Toxicology/ Envionrmental Chemistry, Environmental Impact Assessment, Environmental/Atmospheric Science/Observations, Industrial Waste Management/ Landfill Technology, Biomass/ Alternative Fuel/Renewable Energy, and Environmental Genomics
Nanoscale Sciences and Technology This cluster investigates interactions between noble metal, magnetic and organic nanostructures for developing new sensors; modeling visualization; experimentally developing suitable nanomaterials for the construction of integrated optic chemical sensors	Computational Nanoscience, Nanofabrication, visualization modeling, Nanophotonics, Nanosensors, Synthesis and Characterization, and Applied Material Science
Data Information, Security and Management – This cluster conduct research on nanostorage, nanoRFID, computer forensic and data security	Information Assurance and Computer Security, Information and Intelligent Systems Data, Information, Modeling and Visualization

The research clusters provide a way for departments to organize instruction and student experiences around cluster broad categories that encompass virtually all disciplines from entry through professional levels. This is a combination of engineering, physical sciences, electrical engineering, physics, chemistry and even molecular biology, and many more in STEM fields.

Importantly, the examination of program components, resources, and eligibility factors can help identify areas of potential among collaborators and professionals to maximize resources.

In the same vein, Dr. Wilbur Walters of the Department of Physics, Atmospheric and Geosciences at JSU with a research interest in the development and characterization of novel advanced materials, focusing on thin films, coatings, and nanostructured materials has developed an undergraduate nanoscience curriculum (Introduction to Nanoscale Science). This course aims at enhancing student learning and research opportunities that relate to real-world applications and the use of state-of-the-art instrumentation (Walters 2005). In addition, this course is meant to introduce undergraduate students to nanoscale processing and analysis techniques in the classroom. Through three consecutive NSF grants for Nanoscience Undergraduate Education (NUE) Walters has acquired four Nanosurf Scanning Probe Microscopes (SPMs), two Atomic Force Microscopes (AFMs) and two Scanning Tunneling Microscopes (STMs). This will enhance the teaching of principles of nanoscience and applications to aid hands-on processing laboratories, interactive microscopy learning experience and early research experiences at every level of the curriculum.

Most importantly, majors across the university and their faculty will benefit from the existing cross-teaching with the Department of Physics, Atmospheric and Geosciences that offers students a wide range of opportunities in materials processing, the use of advanced instrumentation, and exposure to cutting-edge topics in nanoscience. Experience using the AFM and STM tools has proven to be a valuable preparation for entering these other research arenas, as shown by feedback from various internship sponsors. Similarly, topics in nanoscale science and other cutting edge research are presented in a weekly seminar series and each semester the seminar features a number of presentations by outside speakers, and a forum where students present their research projects. Through this media, students and faculty members that are new to this field from other departments are eligible to participate in the lectures and seminars series to enhance the hands-on application of the AFM and STM tools.

Because of the concern for selecting and structuring knowledge about joint effort across the STEM fields, the synthesis of ideas would lead to a consensus on the part of STEM faculty participating. Therefore the challenge of the rapid evolution of technological knowledge base leaning on the side of one discipline will `be minimized and importantly STEM faculty members will continue to participate effectively and as well be able to place priority on the ability to identify and structure appropriate knowledge for instruction. This will make it possible for STEM faculty to rely on many sources of curriculum materials and their abilities to synthesize technological information that is integrative of all STEM disciplines (Zuga 1991). In order to unite knowing and doing in an effort to develop valuing, the expertise of integrating content and practice across STEM fields is one of the major contributions STEM educators will make to knowledge sharing.

Utilization of the core laboratories and facilities

According to Melton (2002), "no program can provide all things to those who are in need of services. No budget can provide the resources to assist all of those in need." Collaboration and cooperation is strengthened by sharing resources especially when there is shortage of required resources and expertise among collaborators. "The essence of collaboration is resource sharing since organizational priorities and institutional pride are based in resource allocation and utilization" (Melton 2002). Thus, resource sharing represents commitment to something larger than the single focused discipline goals and objectives and a shift to enter into relationships with other disciplines or fields to achieve shared goals, visions and response to mutual interest and obligations, just as evident in STEM disciplines.

Resource sharing requires development and enhancement of relationships and commitment to achieve something through that relationship, which may not otherwise be achievable by an individual agency or organization. Melton (2002) stated further that there are several requirements to develop and nurture strong relationships and commitment. This he described as people and organizations taking large doses of "Vita-C". Vita-C describes action words connoting a commitment to develop and enhance relationships and includes:

- Collaboration: literally means working together.
- Coordination: arrangement in proper order or proper relation.
- Communication: a giving of information.
- Consultation: the act of seeking information or advice.
- Cooperation: the act of working together in united effort or labor.
- Clarity: clearness.
- Creativity: the quality of being creative (inventive, productive, constructive).
- Courage: bravery, meeting danger without fear.

Collaboration can eliminate redundancy and overlapping that results in inefficient use of resources and the duplication of services (Gallagher, Clifford, & Maxwell, 2004). The core laboratories and facilities at JSU provide researchers with adequate resources such as equipment, technologies, and support functions to enhance research capabilities and for instructional delivery on basic nanofabrication technology. Currently, cross-teaching is in existence among faculty members from Departments of Technology and Physics with the utilization of some of these facilities and laboratories to enhance nanofabrication hands-on experience. Some of the major laboratories and facilities are:

1) The 3 – Modeling laboratory
2) Nanoscience Core Laboratory
3) Molecular Magnetic Resonance Core Laboratory
4) The Computational Modeling Core Laboratory/Supercomputer Center
5) The Visualization Core Laboratory
6) GIS Remote Sensing Laboratory.

Utilizing the existing core laboratories and facilities to enhance basic nanofabrication technology at JSU requires participating faculty members:

- To be able to explain concepts in physical science to both non-experts and experts acquiring knowledge of nanoscale science and technology with more emphasis on the "know how"
- To help set the directions and priorities of the use of core facilities to aid further research activities in nano-science and technology
- To facilitate learning by gaining experience in advanced micro- and nano-fabrication methods as applicable STEM fields
- To assist national users working on their nanofabrication projects in the core facilities
- To establish and maintain baseline fabrication processes as well as introduce and develop advanced process methods and train users in these methods.
- To support the mutual needs of business, industry, and academia by providing mechanisms for technical exchange and collaboration.

Given the aforementioned as laid down in the CSET at JSU, there is a need to develop a new academic program aimed at a commitment to undergraduate and graduate teaching in the emerging fields. Currently, a new masters of science in technology degree (interdisciplinary curricula) to be offered at Jackson State University will serve as the pathway to an education in nanotechnology with nanofabrication as one of the concentrations as an example. Therefore, there is a further need to hire individuals with demonstrated excellent research potential, teaching ability, with relevant industrial experience and expertise in the sub group areas. The awareness and the minimization of the barriers to the success of collaboration among STEM educators should be identified and dealt with carefully. The following should be noted:

Building Consensus among participants

Consensus building among collaborators has to be guided to ensure that the community as a whole participated in all activities that led to the conclusive or winning solutions. Sometimes, to maintain harmony in the collaboration, technological compromises should be embraced as long as they will not affect the quality. In a situation like this, process efficiency and cost efficiency might be sacrificed, as long as the functioning of the collaboration would not be jeopardized.

Being Open and Inclusive

Sense of belonging among participants should be promoted with the understanding that the collective wisdom of the collaboration is far greater than that of any one individual. Importantly, any proposed idea that is rejected with reasons is not a sign of weakness.

Leading by encouraging

There is always another day when the affected members will be able to participate fruitfully. Even, they may be offered the opportunity to contribute to the chosen solution. As such, regular meetings should be open to all to facilitate openness and knowledge sharing and all recorded contributions should be made available to anyone to download ahead of time.

Postponing Decision Making to Manage Risks

Decision making should not be rushed since accountability is the responsibility of the participants. This is necessary to avoid unnecessary risks that might be costly eventually along the road. So, this process is slow and should be consensus-driven. “The whole point, however, is that you leave the decision… to the last possible moment – that way you reduce uncertainty. That is the only way. You have to leave the possibility of reducing uncertainty, rather than fixing the risks.

Teams and technology Interactions over time

Implementing new technology in collaboration activities with shortage in funds and skills is challenging because of the perceived risk of damage or breakage. Understanding the learning process is therefore critical, both for host of facilities with technologies and for technological novice seeking to adopt them. A specific barrier to learning that these teams may face is the need to take time out to train their colleagues need for collaborating teams to relearn how to work together. There should be comfort in technological sharing and usage among collaborators when it is necessary to share equipment. Use practices should not vary among participants to the extent of dominating one another rather than to collaborate. If the most consistent pattern is the use of technology to dominate rather than to collaborate, this will result to negative outcomes (DeSanctis, Poole, and Dickson 2000). However, rules and regulations that guide the way the laboratory equipment are used must be strictly adhered to. The regulations should include the necessary safety precautions, unnecessary trials and errors that may lead to breakage or bodily injury leading to unnecessary cost bearing for the host, among other things.

Knowledge acquisition in virtual teams

How individuals acquire knowledge through group experiences and how technologies used by virtual teams will affect this process should be thoroughly investigated so as to promote the success of the collaboration effort. Collaborators can acquire knowledge in two ways: via other group members and through products that groups generate. With respect to acquisition via group members, how collaborative processes provide opportunities for learning should be emphasized. With respect to knowledge transfer via group products, particular attention should be paid to the mechanisms by which group members store knowledge. This is necessary because information and communication technologies can influence these mechanisms for knowledge acquisition when working in virtual teams. Since there are numerous challenges to knowledge acquisition in distributed groups, it is suggested that all collaborators must be briefed and brought to almost the same level of knowledge of the technological mechanisms to be adopted for enhancing opportunities for learning in virtual teams (Straus and Olivera 2000).

Conclusion

Partnership among scholars from various departments (cluster groups) in the university will enable further knowledge sharing with effective cost saving in the preparation of the future workforce for the emerging fields that will be developed by the integration of STEM disciplines. Given the fact that the equipment needed in any collaborative facility is expensive, existing core laboratories and facilities could serve as the appropriate starting point.

Collaboration in the STEM fields will be effective if only the capacity of all involved work for one another and go beyond personal recognition. Authority should come out of respect from peers and never to be used to coerce. Leadership in collaboration should mean stewardship. With all these put together effectively, higher institutions will be able to reduce and manage projects with high uncertainty, complexity and risk.

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